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(54) CORE-SHEATH COMPOSITE CROSS-SECTION FIBER HAVING EXCELLENT MOISTURE ABSORBENCY AND WRINKLE PREVENTION

(57) A core-sheath composite cross-section fiber characterized in that the core section polymer is a thermoplastic polymer, the sheath-section polymer is a polyamide having a dicarboxylic acid unit which has a sebacic acid unit as a main component, the boiling-water shrinkage ratio is 6.0-12.0%, and the stress per unit fineness during 3% elongation in a fiber tensile test is 0.60 cN/dtex or more. A core-sheath composite cross-section fiber is provided having excellent moisture-absorbing capability and wrinkling prevention, and in which the moisture-absorbing capability is maintained even when washed.

EP 3 375 918 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a core-sheath composite cross-section fiber excellent in moisture absorbency and wrinkle prevention.

BACKGROUND ART

[0002] Synthetic fibers made from thermoplastic resins such as polyamides and polyesters are widely used in clothing applications, industrial applications and the like because they are excellent in strength, chemical resistance, heat resistance and the like.

[0003] In particular, polyamide fibers are excellent in moisture absorbing and releasing performance in addition to characteristics such as distinctive softness, high tensile strength, coloring property at dyeing, and high heat resistance, and are widely used in underwear, sportswear, and the like. Polyamide fibers, however, are still insufficient in moisture absorbing and releasing performance as compared with natural fibers such as cotton, and have problems such as stuffy and sticky feeling. Thus, polyamide fibers are inferior to natural fibers in terms of wearing comfort.

[0004] From such a background, synthetic fibers that exhibit excellent moisture absorbing and releasing performance for preventing stuffy and sticky feeling, and that give wearing comfort comparable to that of natural fibers are demanded mainly for underwear and sportswear applications.

[0005] In view of this, Patent Document 1 discloses a core-sheath composite cross-section fiber made of a core section and a sheath section, the core section being not exposed to the fiber surface, in which the core section is made from a polyether block amide copolymer having polycaproamide as a hard segment, the sheath section is made from polycaproamide, and the area ratio of the core section to the sheath section in the fiber cross-section is 3/1 to 1/5.

[0006] Moreover, Patent Document 2 discloses a core-sheath composite cross-section fiber excellent in moisture absorbing and releasing performance, the core-sheath composite cross-section fiber having a core section made from a thermoplastic polymer and a sheath section made from a fiber-forming polyamide, in which the thermoplastic polymer forming the core section contains a polyether ester amide copolymer as a main component, and the percentage of the core section is 5 to 50% by weight of the total weight of the composite fiber.

[0007] Moreover, Patent Document 3 discloses a core-sheath composite cross-section fiber excellent in antistatic performance, water absorption performance, and cool contact feeling, the core-sheath composite cross-section fiber having a core section made from a polyether block amide copolymer and a sheath section made from a fiber-forming polymer such as a polyamide or a polyester, in which the core section is exposed at an exposure angle in the range of 5° to 90°. The core-sheath composite cross-section fibers of Patent Documents 1 to 3 are increasingly used as woven or knitted fabrics for underwear and sports applications.

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

[0008]

Patent Document 1: International Publication No. 2014/10709
Patent Document 2: Japanese Patent Laid-open Publication No. 6-136618
Patent Document 3: International Publication No. 2008/123586

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0009] Although the core-sheath composite cross-section fibers of Patent Documents 1 to 3 are excellent in moisture absorbing and releasing performance due to the high moisture-absorbing capability of the core component polymer, the core-sheath composite cross-section fibers are easily deformed and wrinkled in the dyeing step because they are made from flexible polymers having high shrinkage characteristics. Moreover, such phenomenon easily occurs also during washing. Furthermore, the core-sheath composite cross-section fibers also have problems that the core section is deteriorated due to repeated actual use, and the moisture-absorbing capability decreases due to repeated use.

SOLUTIONS TO THE PROBLEMS

[0010] It is an object of the present invention to overcome the problems of the prior techniques and to provide a core-sheath composite cross-section fiber excellent in moisture absorbing and releasing performance and wrinkle prevention. It is another object of the present invention to provide a core-sheath composite cross-section fiber that maintains the moisture-absorbing capability even after being washed.

[0011] In order to solve the above-mentioned problems, the present invention has the following constitution.

(1) A core-sheath composite cross-section fiber, containing: a thermoplastic polymer as a core polymer; and a polyamide having a dicarboxylic acid unit having, as a main component, a sebacic acid unit as a sheath polymer, the core-sheath composite cross-section fiber having a boiling-water shrinkage ratio of 6.0 to 12.0%, and a stress per unit fineness during 3% elongation in a fiber tensile test of 0.60 cN/dtex or more.

(2) The core-sheath composite cross-section fiber according to (1), wherein a sheath section has an α-crystal orientation parameter of 2.10 to 2.70.

(3) The core-sheath composite cross-section fiber according to (1) or (2), having a retention rate of stress per unit fineness during 3% elongation in a fiber tensile test of 60% or more before and after boiling water treatment.

(4) A fabric including the core-sheath composite cross-section fiber according to any one of (1) to (3) in at least a part thereof.

(5) A textile product including the core-sheath composite cross-section fiber according to any one of (1) to (3) in at least a part thereof.

EFFECTS OF THE INVENTION

[0012] According to the present invention, it is possible to provide a core-sheath composite cross-section fiber that is excellent in moisture-absorbing capability and wrinkle prevention, and that maintains the moisture-absorbing capability even after being washed.

EMBODIMENTS OF THE INVENTION

[0013] The core-sheath composite cross-section fiber of the present invention contains a polyamide having a dicarboxylic acid unit having, as a main component, a sebacic acid unit as a sheath polymer, and a thermoplastic polymer having high moisture-absorbing capability as a core polymer.

[0014] The polyamide having a dicarboxylic acid unit having, as a main component, a sebacic acid unit in the sheath section is a polymer made from a so-called high molecular weight material in which a hydrocarbon is linked to a main chain via an amide bond, and specific examples of the polyamide include polypentamethylene sebacamide, polyhexamethylene sebacamide, and copolymers thereof. From the viewpoint of economy, relatively easy yarn making, and excellent dyeability and mechanical characteristics, such a polyamide is preferably a polyamide mainly including polyhexamethylene sebacamide.

[0015] The polyamide having a dicarboxylic acid unit having, as a main component, a sebacic acid unit in the sheath section may contain various additives, such as a matting agent, a flame retardant, an antioxidant, an ultraviolet absorber, an infrared absorber, a crystal nucleating agent, a fluorescent whitening agent, an antistatic agent, a hygroscopic polymer, and carbon in the form of a copolymer or a mixture as needed at a total additive content of 0.001 to 10% by weight.

[0016] The thermoplastic polymer having high moisture-absorbing capability in the core section refers to a polymer having a ΔMR as measured in a pellet form of 10% or more, and examples thereof include a polyether ester amide copolymer, polyvinyl alcohol, and a cellulose thermoplastic polymer. Among these, a polyether ester amide copolymer is preferable from the viewpoint of high thermal stability, high compatibility with the polyamide in the sheath section, and excellent peeling resistance.

[0017] The "ΔMR" as used herein means a value obtained in the following manner. About 1 to 2 g of pellets are weighed in a weighing bottle, the pellets are dried at 110°C for 2 hours and the weight (W0) is measured, and then the pellets are held at 20°C and a relative humidity of 65% for 24 hours and the weight (W65) is measured. Then, the pellets are held at 30°C and a relative humidity of 90% for 24 hours and the weight (W90) is measured. The ΔMR is calculated according to the following formulae.

$$MR65\ (\%) = [(W65 - W0)/W0] \times 100$$

$$MR90\ (\%) = [(W90 - W0)/W0] \times 100$$

$$\Delta MR\ (\%) = MR90 - MR65$$

[0018] A polyether ester amide copolymer is a block copolymer having an ether bond, an ester bond, and an amide bond in one molecular chain. More specifically, a polyether ester amide copolymer is a block copolymer obtained by the polycondensation reaction of at least one polyamide component (A) selected from lactams, aminocarboxylic acids, and salts of diamines and dicarboxylic acids, with a polyether ester component (B) formed of a dicarboxylic acid and a poly(alkylene oxide) glycol.

[0019] Examples of the polyamide component (A) include lactams such as ε-caprolactam, dodecanolactam, and undecanolactam, ω-aminocarboxylic acids such as aminocaproic acid, 11-aminoundecanoic acid, and 12-aminododecanoic acid, and nylon salts of diamines and dicarboxylic acids, which are precursors of polyhexamethylene adipamide, polyhexamethylene sebacamide, polyhexamethylene dodecanamide and the like. A preferable polyamide component is ε-caprolactam.

[0020] The polyether ester component (B) is formed of a dicarboxylic acid having 4 to 20 carbon atoms and a poly(alkylene oxide) glycol. Examples of the dicarboxylic acid having 4 to 20 carbon atoms include aliphatic dicarboxylic acids such as succinic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, sebacic acid, and dodecanoic acid, aromatic dicarboxylic acids such as terephthalic acid, isophthalic acid, and 2,6-naphthalenedicarboxylic acid, and alicyclic dicarboxylic acids such as 1,4-cyclohexanedicarboxylic acid. One of them or a mixture of two or more of them can be used. Preferable dicarboxylic acids are adipic acid, sebacic acid, dodecanoic acid, terephthalic acid, and isophthalic acid. Examples of the poly(alkylene oxide) glycol include polyethylene glycol, poly (1,2- and 1,3-propylene oxide) glycol, poly(tetramethylene oxide) glycol, and poly(hexamethylene oxide) glycol. Polyethylene glycol having particularly high moisture-absorbing capability is preferable.

[0021] The number average molecular weight of the poly (alkylene oxide) glycol is preferably from 300 to 10,000, more preferably from 500 to 5,000. A molecular weight of 300 or more is preferable because the poly(alkylene oxide) glycol hardly scatters to the outside of the system during the polycondensation reaction, and a fiber having stable moisture-absorbing capability is obtained. Meanwhile, a molecular weight of 10,000 or less is preferable because a homogeneous block copolymer is obtained and the yarn making property is stabilized.

[0022] The composition rate of the polyether ester component (B) is preferably from 20 to 80% in terms of the molar ratio. A composition rate of 20% or more is preferable because high moisture absorbency can be obtained. A composition rate of 80% or less is preferable because high color fastness and washing durability can be obtained.

[0023] As such a polyether ester amide copolymer, "MH1657" and "MV1074" manufactured by ARKEMA K.K. and the like are commercially available.

[0024] The core-sheath composite cross-section fiber of the present invention is required to have a boiling-water shrinkage ratio of 6.0 to 12.0%. If the boiling-water shrinkage ratio exceeds 12.0%, the fiber is easily deformed and wrinkled in the dyeing step. If the boiling-water shrinkage ratio is less than 6.0%, although the fiber is excellent in wrinkle prevention, there are cases where the operability in the yarn making step is deteriorated or the quality is deteriorated. A boiling-water shrinkage ratio within the above-mentioned range gives a fiber excellent in wrinkle prevention. The boiling-water shrinkage ratio is preferably from 6.0 to 10.0%.

[0025] The core-sheath composite cross-section fiber of the present invention is required to have a stress per unit fineness during 3% elongation in a fiber tensile test of 0.60 cN/dtex or more. The stress during 3% elongation in a fiber tensile test is obtained by subjecting a sample to a tensile test under the constant rate extension conditions shown in JIS L1013 (Chemical fiber filament yarn test method, 2010), and obtaining the strength at 3% elongation of the sample in a tensile strength-elongation curve for the determination of the stress. This strength is divided by the fineness of the fiber to obtain the stress per unit fineness during 3% elongation in a fiber tensile test.

[0026] The stress per unit fineness during 3% elongation in a fiber tensile test corresponds to a rising portion of the tensile strength-elongation curve, and is a parameter that shows the rigidity of the fiber. The larger the value is (the steeper the rise of the tensile strength-elongation curve is), the more rigid the fiber is. That is, a fiber having a stress per unit fineness during 3% elongation in a fiber tensile test of 0.60 cN/dtex or more is suppressed in deformation in the dyeing step, and is excellent in wrinkle prevention. The stress per unit fineness during 3% elongation in a fiber tensile test is preferably 0.70 cN/dtex or more.

[0027] In the core-sheath composite cross-section fiber of the present invention, the polyamide in the sheath section preferably has an α-crystal orientation parameter of 2.10 to 2.70, more preferably from 2.20 to 2.60. It is generally known that an α-crystal is a stable crystal form, and is formed when high stress is applied. When the polyamide in the sheath section has an α-crystal orientation parameter within the above-mentioned range, the polyamide in the sheath section

is preferentially stretched between a stretching roller and a take-up roller from the spinning to the take-up, so that sufficient α-crystals as a stable crystal form can be made present. As a result, at the time of melt spinning, the stretching force concentrates on the polyamide in the sheath section, and the thermoplastic polymer having high moisture-absorbing capability in the core section is suppressed in crystallization. As a result, the moisture-absorbing capability of the core-sheath composite fiber can be further increased, and at the same time, the rigidity of the sheath section is increased, so that the tensile stress of the core-sheath composite fiber can be further increased.

[0028] When the polyamide in the sheath section has an α-crystal orientation parameter of 2.10 or more, the crystallization of the polyamide in the sheath section proceeds, and the core-sheath composite cross-section fiber is improved in the tensile stress during 3% elongation, and moreover, the crystallization of the thermoplastic polymer having high moisture-absorbing capability in the core section does not proceed, and the core-sheath composite cross-section fiber is also improved in the moisture absorbing and releasing performance. On the other hand, when the polyamide has an α-crystal orientation parameter of 2.70 or less, the crystallization of the polyamide in the sheath section does not proceed, and yarn breakage and generation of fluff in the higher order processing steps can be suppressed, so that productivity is improved.

[0029] The core-sheath composite cross-section fiber of the present invention preferably has a retention rate of stress per unit fineness during 3% elongation in a fiber tensile test of 60% or more before and after boiling water treatment. When the retention rate of stress per unit fineness is within the above-mentioned range, changes in the fiber structure and crystal orientation degree in the dyeing step are small, the shrinkage of the fiber is suppressed, and the rigidity of the fiber is also easily maintained, so that it is possible to obtain a fiber excellent in wrinkle prevention. In a fiber subjected to boiling water treatment, the fiber structure is changed mainly in an amorphous part, hydrogen bonds between amide bonds in the amorphous part are broken, the mobility of the molecular chain is improved, and the orientation degree is lowered. As a result of the changes in the fiber structure in the amorphous part and the orientation degree, the fiber shrinks and the rigidity of the fiber decreases. Therefore, suppressing the shrinkage of the fiber as much as possible and maintaining the rigidity of the fiber as much as possible before and after the boiling water treatment suppress the deformation of the fiber and improve the wrinkle prevention in the dyeing step. Furthermore, deformation of the fiber is suppressed and the wrinkle prevention is improved also during washing.

[0030] The thermoplastic polymer having high moisture-absorbing capability in the core section, which constitutes the core-sheath composite cross-section fiber of the present invention, is a polymer having low crystallinity and poor rigidity. Therefore, the polymer comes to have high shrinkage characteristics and is easily increased in flexibility due to boiling water treatment. Therefore, in the core-sheath composite cross-section fiber of the present invention, a polyamide including polyhexamethylene sebacamide having relatively high rigidity and low shrinkability is selected from polyamides as the sheath polymer to impart rigidity to the sheath section, and further the fiber is made under specific yarn making conditions (such as the heat setting temperature and the lubrication position) as will be described later to suppress the shrinkage characteristics and improve the rigidity, so that the wrinkle prevention and moisture-absorbing capability are improved. The retention rate of stress per unit fineness is more preferably 70% or more.

[0031] The core-sheath composite cross-section fiber of the present invention preferably has a tensile strength of 3.0 cN/dtex or more, more preferably from 3.5 to 5.0 cN/dtex. A tensile strength within the above-mentioned range makes it possible to provide a product excellent in durability in practical use.

[0032] The core-sheath composite cross-section fiber of the present invention preferably has a degree of elongation of 35% or more, more preferably from 40 to 65%. A degree of elongation within the above-mentioned range improves the passability of the fiber in the higher order steps such as weaving, knitting, and false twisting.

[0033] In order to give high wearing comfort, the core-sheath composite cross-section fiber of the present invention is required to have a function of adjusting the humidity inside the clothes. As an indicator of humidity adjustment, ΔMR is used. The ΔMR is represented by the difference in moisture absorptivity between that at the temperature and humidity inside the clothes typified by 30°C × 90% RH in work on light to medium duty or light to medium exercise, and that at the outside temperature and humidity typified by 20°C × 65% RH. The larger the ΔMR is, the higher the moisture-absorbing capability is, and a larger ΔMR corresponds to higher wearing comfort.

[0034] The core-sheath composite cross-section fiber of the present invention preferably has a ΔMR of 5.0% or more. The ΔMR is more preferably 7.0% or more, still more preferably 10.0% or more. A ΔMR within the above-mentioned range makes it possible to suppress stuffy and sticky feeling during wearing, and to provide clothing excellent in comfort.

[0035] The core-sheath composite cross-section fiber of the present invention preferably has a ΔMR retention rate after 20 times of washing of 90% or more and 100% or less. The ΔMR retention rate is more preferably 95% or more and 100% or less. A ΔMR retention rate within the above-mentioned range provides washing durability against actual use, so that it is possible to provide clothing that maintains excellent comfort. Furthermore, a core-sheath composite cross-section fiber having a ΔMR of 5.0% or more and a ΔMR retention rate after 20 times of washing of 90% or more can provide clothing excellent in comfort that has washing durability against actual use.

[0036] The core-sheath composite cross-section fiber of the present invention may be either of a filament and a staple depending on the application. The total fineness, the number of filaments (in the case of a long fiber), and the length

and number of crimps (in the case of a short fiber) are also not particularly limited, but the total fineness is preferably from 5 to 235 dtex and the number of filaments is preferably from 1 to 144 in consideration of the use as a long fiber material for clothing.

[0037] The core-sheath composite cross-section fiber of the present invention can be obtained by techniques such as melt spinning and composite spinning. Examples of the spinning technique are as follows. For example, a polyamide (sheath section) and a thermoplastic polymer having high moisture-absorbing capability (core section) are separately melted, and metered and transported with a gear pump, a composite flow is directly formed and discharged from a melt spinneret, and the obtained yarns are cooled to room temperature with a yarn cooling device such as a chimney, lubricated and bundled with a lubrication device, entangled with a first fluid entangling nozzle device, and stretched according to the ratio of the circumferential speed between a take-up roller and a stretching roller. Then, the yarns are heat-set with the stretching roller, and wound up with a winder (winding device) .

[0038] In order to obtain the core-sheath composite cross-section fiber of the present invention, it is preferable to select a polyamide having an appropriate molecular structure, and to adopt a suitable take-up speed, a suitable lubrication position, and a suitable heat setting temperature after stretching. These will be described in detail below.

[0039] As described above, the polyamide used in the sheath section of the core-sheath composite cross-section fiber of the present invention is preferably a polyamide having a dicarboxylic acid unit having, as a main component, a sebacic acid unit, that is, a polymer made from a so-called high molecular weight material in which a hydrocarbon is linked to a main chain via an amide bond. Selecting a polyamide having a high capability of forming a hydrogen bond between amide bonds for the sheath section provides a core-sheath composite cross-section fiber in which a hydrogen bond between amide bonds in an amorphous part is hardly broken even at dyeing and drying at a high temperature exceeding 100°C, and which is reduced in changes in the fiber structure of the sheath section and excellent in wrinkle prevention of the fabric at dyeing. The "capability of forming a hydrogen bond between amide bonds" as used herein is determined by the degree of freedom of the main chain of the polyamide molecule, that is, the number of methylene groups per one amide bond. Therefore, selecting such a polyamide for the sheath section provides a core-sheath composite cross-section fiber excellent in wrinkle prevention of the fabric at dyeing.

[0040] The polyamide used in the core-sheath composite cross-section fiber of the present invention may contain various additives, such as a matting agent, a flame retardant, an antioxidant, an ultraviolet absorber, an infrared absorber, a crystal nucleating agent, a fluorescent whitening agent, an antistatic agent, a hygroscopic polymer, and carbon in the form of a copolymer or a mixture as needed at a total additive content of 0.001 to 10% by weight.

[0041] The polyamide chip used in the core-sheath composite cross-section fiber of the present invention preferably has a sulfuric acid relative viscosity of 2.30 to 3.30. A sulfuric acid relative viscosity within the above-mentioned range makes it possible to appropriately stretch the polyamide in the sheath section. When the sulfuric acid relative viscosity of the polyamide in the sheath section is 2.30 or more, a practically usable fiber strength and elongation is obtained. On the other hand, when the sulfuric acid relative viscosity is 3.30 or less, since the polyamide has a melt viscosity suitable for spinning, the stringing property during melt spinning is improved, and a fiber can be stably produced with no yarn breakage. The sulfuric acid relative viscosity is more preferably from 2.50 to 3.10.

[0042] The proportion of the core section in the core-sheath composite cross-section fiber of the present invention is preferably from 20 parts by weight to 80 parts by weight to 100 parts by weight of the composite fiber. The proportion of the core section is more preferably from 30 parts by weight to 70 parts by weight. A proportion of the core section within the above-mentioned range makes it possible to appropriately stretch the polyamide in the sheath section. In addition, such a proportion gives high color fastness and moisture-absorbing capability.

[0043] The temperature in the melting step is preferably from 250 to 290°C for the case of a polyhexamethylene sebacamide chip as the polyamide having a dicarboxylic acid unit having, as a main component, a sebacic acid unit used in the sheath section, and is preferably from 220 to 260°C for the case of "MH1657" manufactured by ARKEMA K.K. as the thermoplastic polymer having high moisture-absorbing capability used in the core section.

[0044] In the take-up step, the take-up speed is preferably from 2500 to 3400 m/min. A take-up speed within the above-mentioned range makes the orientation crystallization of the core polymer moderately proceed and moderately suppress the crystallization of the core polymer, so that the stress per unit fineness during 3% elongation and the boiling-water shrinkage ratio can be controlled within preferable ranges, and the fiber is excellent in moisture-absorbing capability and wrinkle prevention, and can maintain the moisture-absorbing capability even after being washed. A take-up speed exceeding 3400 m/min makes the orientation crystallization of the polyamide in the sheath section proceed during stretching with spinning tension, but the α-crystal orientation parameter of the polyamide in the sheath section decreases, the rigidity of the sheath polymer decreases, and the fiber may be easily wrinkled due to a low mechanical stretch ratio. A take-up speed less than 2500 m/min provides a high mechanical stretch ratio, but due to insufficient stretching by the spinning tension, the α-crystal orientation parameter of the polyamide in the sheath section decreases, the rigidity of the sheath polymer decreases, and the fiber may be easily wrinkled. In addition, orientation crystallization of the core polymer proceeds, and the moisture-absorbing capability decreases. The take-up speed is more preferably from 2700 to 3200 m/min.

[0045] In the lubricating step, the lubrication position is preferably at a position from 800 to 1500 mm from the lower surface of the spinneret. The polymer discharged from the spinneret is blown with cooling air from a cooling device to be solidified into yarns, and the yarns are stretched in the section from the solidification position to the lubrication position by spinning tension with accompanying flow, and then mechanically stretched between the take-up roller and the stretching roller. As for the core-sheath composite cross-section fiber of the present invention, it is important to increase the mechanical stretch ratio in order to promote the orientation crystallization of the sheath polymer to increase the rigidity, and to decrease the spinning tension in order to suppress the orientation crystallization of the core polymer to improve the moisture-absorbing capability. In other words, setting the lubrication position at a position within the above-mentioned range makes it possible to increase the stress per unit fineness during 3% elongation in a fiber tensile test, and to provide a fiber excellent in wrinkle prevention and moisture-absorbing capability. If the lubrication position is at a position less than 800 mm from the lower surface of the spinneret, the yarns are largely bent between the spinneret and the lubrication position, and an oil is supplied to the yarns in a state where the yarns are not sufficiently solidified, so that yarn breakage frequently occurs and the operability may be deteriorated. On the other hand, if the lubrication position is at a position more than 1500 mm from the lower surface of the spinneret, not only the orientation crystallization of the core polymer proceeds due to the high spinning tension to decrease the moisture-absorbing capability, but also the rigidity of the sheath polymer decreases, and the fiber may be easily wrinkled due to a low mechanical stretch ratio. The lubrication position is more preferably at a position from 1000 to 1300 mm from the lower surface of the spinneret.

[0046] In the stretching step, the temperature of the heat setting after stretching is preferably from 165 to 180°C. The fiber oriented and crystallized by stretching between the rollers is further crystallized by the high-temperature heat setting treatment on a heating roller, so that the fiber structure is stabilized. The boiling-water shrinkage ratio depends on the shrinkage of the amorphous part of the fiber, that is, the proportion of the amorphous part. The "heat setting temperature" as used herein means the set temperature of the heating roller.

[0047] The polymer having high moisture-absorbing capability in the core section, which constitutes the core-sheath composite cross-section fiber of the present invention, has high amorphous properties and high shrinkability. Therefore, a fiber made from only the single polymer is expected to have a large boiling-water shrinkage ratio. In view of the above, the core-sheath composite cross-section fiber of the present invention contains, as a sheath polymer, a polyamide having a dicarboxylic acid unit having, as a main component, a sebacic acid unit, which has relatively high rigidity and low shrinkability among polyamides, to impart rigidity to the sheath section and suppress the shrinkability of the core section. Moreover, heat setting at a temperature within the above-mentioned range after the stretching can stabilize the fiber structure, control the boiling-water shrinkage ratio within the range of 6.0 to 12.0%, and provide a fiber excellent in wrinkle prevention. If the heat setting temperature is lower than 165°C, the crystallization of the polyamide in the sheath section is insufficient, the fiber structure is not stabilized, and the fiber may be easily wrinkled. On the other hand, if the heat setting temperature exceeds 180°C, although a fiber excellent in wrinkle prevention can be obtained, contamination of the heating roller with a decomposition product of a spinning oil or the like is promoted, deterioration of the quality and breakage of the spun yarns occur frequently, the operability is deteriorated, and the fiber may be deteriorated in the process passability through higher order processing steps. The heat setting temperature is more preferably from 170 to 175°C.

[0048] Since the core-sheath composite cross-section fiber of the present invention is excellent in moisture-absorbing capability, it is preferably used in clothing items, and the fabric form can be selected from a woven fabric, a knitted fabric, a nonwoven fabric and the like according to the purpose. As described above, the larger the ΔMR is, the higher the moisture-absorbing capability is, and a larger ΔMR corresponds to higher wearing comfort. Accordingly, a fabric including the core-sheath composite fiber of the present invention in at least a part thereof, which has a mixing ratio of the composite fiber of the present invention adjusted so that the ΔMR will be 5.0% or more, can provide clothing excellent in comfort. The clothing items may be various textile products such as underwear and sportswear.

EXAMPLES

[0049] Hereinafter, the present invention will be described more specifically by way of examples. Measurement methods and the like of the characteristic values in the examples are as follows.

(1) Sulfuric acid relative viscosity

[0050] A polyamide chip sample (1 g) was dissolved in 100 ml of sulfuric acid having a concentration of 98% by weight, and the flow time (T1) of the resulting solution at 25°C was measured with an Ostwald viscometer. Then, the flow time (T2) of sulfuric acid having a concentration of 98% by weight alone was measured. The ratio of Tl to T2, that is, T1/T2, was taken as the sulfuric acid relative viscosity.

(2) Ortho-chlorophenol relative viscosity (OCP relative viscosity)

[0051] A polyether ester amide copolymer chip sample (1 g) was dissolved in 100 ml of ortho-chlorophenol, and the flow time (T1) of the resulting solution at 25°C was measured with an Ostwald viscometer. Then, the flow time (T2) of ortho-chlorophenol alone was measured. The ratio of T1 to T2, that is, T1/T2, was taken as the ortho-chlorophenol relative viscosity.

(3) Fineness

[0052] A fiber sample was set on a sizing reel having a perimeter of 1.125 m, and rotated 200 times to make a looped skein. The skein was dried (105 $\pm$ 2°C $\times$ 60 minutes) with a hot air dryer, and the skein weight was measured with a scaling balance. The fineness based on corrected mass was calculated from the value obtained by multiplying the skein weight by the official regain.

(4) Strength and degree of elongation

[0053] A fiber sample was measured with "TENSILON" (registered trademark) UCT-100 manufactured by ORIENTEC CORPORATION under the constant rate extension conditions shown in JIS L1013 (Chemical fiber filament yarn test method, 2010). The degree of elongation was determined from the elongation of a point showing the maximum strength in a tensile strength-elongation curve. The strength was a value obtained by dividing the maximum strength by the fineness based on corrected mass. The measurement was carried out 10 times, and the average values were taken as the strength and degree of elongation.

(5) Stress per unit fineness during 3% elongation (stress during 3% elongation)

[0054] A tensile test of a fiber sample was carried out by the method described in the item (4), and the strength at the point where the sample showed 3% elongation in the tensile strength-elongation curve was determined and taken as the stress during 3% elongation. The measurement was carried out 10 times, and the average value was taken as the stress during 3% elongation.

(6) α-Crystal orientation parameter

[0055] A fiber sample was measured by laser Raman spectroscopy, and a ratio between the intensity ratio of Raman bands derived from a nylon α-crystal observed at around 1120 cm^{-1} in parallel polarization ((I1120) parallel) and the intensity ratio of Raman bands in vertical polarization ((I1120) vertical) was obtained as a parameter for the evaluation of orientation degree. Further, the scattering intensity under each polarization condition (parallel/vertical) was normalized on the basis of the Raman band intensity of the CH deformation band (around 1440 cm^{-1}) having small anisotropy of orientation.

$$\alpha\text{-Crystal orientation parameter} = (I1120/I1440)\ \text{parallel}/(I1120/I1440)\ \text{vertical}$$

[0056] The fiber sample for orientation measurement was embedded in a resin (bisphenol type epoxy resin, cured for 24 hours), and then sectioned with a microtome. The section had a thickness of 2.0 μm. The section sample was cut slightly inclined from the fiber axis so that the cut face would have an elliptical shape, and the portion where the thickness of the minor axis of the ellipse was constant was selected and measured. The measurement was performed in the microscopic mode, and the spot diameter of the laser at the sample position was 1 μm. The orientation of the centers of the core and sheath layers was analyzed, and the orientation was measured under polarization conditions. The orientation degree was evaluated based on the ratio between the Raman band intensities obtained under a parallel condition in which the polarization direction coincided with the fiber axis and a vertical condition in which the polarization direction was orthogonal to the fiber axis. The measurement was performed 3 times for each measurement point, and the average thereof was used. Detailed conditions are shown below.

Laser Raman spectroscopy

[0057]

Apparatus: T-64000 (Jobin Yvon/Atago Bussan Co., Ltd.)
Conditions: measurement mode; micro Raman
Objective lens: ×100
Beam diameter: 1 μm
Light source: Ar+ laser/514.5 nm
Laser power: 50 mW
Diffraction grating: Single 600 gr/mm
Slit: 100 μm
Detector: CCD/Jobin Yvon 1024 × 256

(7) Boiling-water shrinkage ratio

[0058] The boiling-water shrinkage ratio was measured according to JIS L1013: 2010 8.18.1 (method B).

(8) Production of woven fabric

[0059] The core-sheath composite cross-section fiber of the present invention was used as the warp and the weft. At a warp density of 188 yarns/2.54 cm and a weft density of 155 yarns/2.54 cm, the fiber was woven into a flat structure with a water jet loom.

[0060] According to a conventional method, the resulting gray fabric was scoured with an open soaper in a solution containing 2 g of caustic soda (NaOH) per liter, dried in a cylinder dryer at 120°C, and then preset at 170°C. Then, the gray fabric was heated to 120°C at a rate of 2.0°C/min in a pressure-resistant drum type dyeing machine, and dyed at a set temperature of 120°C for 60 minutes. After the dyeing, the fabric was washed with running water for 20 minutes, and dehydrated and dried to give a woven fabric having a warp density of 200 yarns/2.54 cm and a weft density of 160 yarns/2.54 cm.

(9) Evaluation of wrinkle prevention

[0061] The woven fabric obtained in the item (8) was subjected to the method described in paragraph 9 of JIS L1059-2 (Testing methods for crease recovery of textiles - Part 2: Evaluation of the wrinkle recovery of fabrics (wrinkle method), 2009), and the wrinkle prevention was judged as Grade 5 (the most smooth appearance) to Grade 1 (the most wrinkly appearance) . When the fabric was judged as Grade 3 or higher, the fabric was judged as being excellent in wrinkle prevention.

(10) ΔMR

[0062] The woven fabric obtained in the item (8) (about 1 to 2 g) was weighed in a weighing bottle, held at 110°C for 2 hours to dry, and the weight (W0) was measured. Then, a target substance was held at 20°C and a relative humidity of 65% for 24 hours, and then the weight (W65) was measured. Then, the target substance was held at 30°C and a relative humidity of 90% for 24 hours, and then the weight (W90) was measured. Then, the ΔMR was calculated according to the following formulae.

$$MR65 = [(W65 - W0)/W0] \times 100\% \quad \ldots\ldots (1)$$

$$MR90 = [(W90 - W0)/W0] \times 100\% \quad \ldots\ldots (2)$$

$$\Delta MR = MR90 - MR65 \quad \ldots\ldots\ldots\ldots (3)$$

(11) ΔMR after washing

[0063] The woven fabric obtained in the item (8) was repeatedly subjected to 20 times of washing by the method described in No. 103 in the attached table 1 of JIS L0217 (1995), and then the ΔMR described in the item (10) was calculated.

[0064] When the ΔMR was 5.0% or more, the woven fabric was judged to give high wearing comfort.

(12) ΔMR retention rate after washing

[0065] The ΔMR retention rate after washing was calculated according to the following formula as an index of change of ΔMR before and after washing.

$$(\Delta MR \text{ after washing treatment} - \Delta MR \text{ before washing treatment})/\Delta MR \text{ before washing treatment} \times 100$$

[0066] When the ΔMR retention rate was 90% or more, the fabric was judged as having washing durability.

(13) Process passability through higher order processing steps

[0067] Using the core-sheath composite cross-section fiber of the present invention, 10 pieces (1000 m/piece) of plain weave fabrics were woven with a water jet loom at a loom rotation speed of 750 rpm and a weft length of 1620 mm. The number of stoppage of the loom due to yarn breakage during the weaving was evaluated. When the number of yarn breakage was 2 times or less, the fiber was judged to be good in process passability.

(Example 1)

[0068] A polyether ester amide copolymer (MH1657 manufactured by ARKEMA K.K. (chip ΔMR: 18.9)) having an ortho-chlorophenol relative viscosity of 1.69 as a core section, and nylon 610 having a sulfuric acid relative viscosity of 2.72 as a sheath section were melted at 270°C, and spun from a concentric core-sheath composite spinneret so that the core/sheath ratio (parts by weight) would be 50/50.

[0069] In this process, the rotation speed of the gear pump was selected so that the obtained core-sheath composite yarn would have a total fineness of 56 dtex, and the polymers were each discharged at 22 g/min. Then, the yarns were cooled and solidified with a yarn cooling device, and an anhydrous oil was supplied with a lubrication device from a lubrication position at a position of 1000 mm from the lower surface of the spinneret. Then, the yarns were entangled with a first fluid entangling nozzle device, stretched at a circumferential speed of a take-up roller as a first roll of 2800 m/min and a stretch ratio between the take-up roller and a stretching roller of 1.50 times, and heat-set at a set temperature of the stretching roller of 170°C. Then, the yarns were wound up at a winding speed of 4000 m/min to give a core-sheath composite cross-section fiber of 56 dtex/24 filaments.

[0070] For the obtained core-sheath composite cross-section fiber, the fineness, strength, degree of elongation, stress per unit fineness during 3% elongation, boiling-water shrinkage ratio, retention rate of stress per unit fineness during 3% elongation before and after boiling water treatment, and α-crystal orientation parameter were measured. The obtained woven fabric was evaluated for wrinkle prevention, ΔMR, ΔMR after washing, and ΔMR retention rate after washing. The results are shown in Table 1.

(Example 2)

[0071] A core-sheath composite cross-section fiber of 56 dtex/24 filaments was obtained in the same manner as in Example 1 except that the heat setting temperature of the heating roller was 180°C.

[0072] For the obtained core-sheath composite cross-section fiber, the fineness, strength, degree of elongation, stress per unit fineness during 3% elongation, boiling-water shrinkage ratio, retention rate of stress during 3% elongation before and after boiling water treatment, and α-crystal orientation parameter were measured. The obtained woven fabric was evaluated for wrinkle prevention, ΔMR, ΔMR after washing, and ΔMR retention rate after washing. The results are shown in Table 1.

(Example 3)

[0073] A core-sheath composite cross-section fiber of 56 dtex/24 filaments was obtained in the same manner as in Example 1 except that the heat setting temperature of the heating roller was 165°C.

[0074] For the obtained core-sheath composite cross-section fiber, the fineness, strength, degree of elongation, stress per unit fineness during 3% elongation, boiling-water shrinkage ratio, retention rate of stress during 3% elongation before and after boiling water treatment, and α-crystal orientation parameter were measured. The obtained woven fabric was evaluated for wrinkle prevention, ΔMR, ΔMR after washing, and ΔMR retention rate after washing. The results are shown in Table 1.

(Example 4)

[0075] A core-sheath composite cross-section fiber of 56 dtex/24 filaments was obtained in the same manner as in Example 1 except that the lubrication position was at a position of 1500 mm from the lower surface of the spinneret, and the yarns were wound up at a winding speed of 3900 m/min.

[0076] For the obtained core-sheath composite cross-section fiber, the fineness, strength, degree of elongation, stress per unit fineness during 3% elongation, boiling-water shrinkage ratio, retention rate of stress during 3% elongation before and after boiling water treatment, and α-crystal orientation parameter were measured. The obtained woven fabric was evaluated for wrinkle prevention, ΔMR, ΔMR after washing, and ΔMR retention rate after washing. The results are shown in Table 1.

(Example 5)

[0077] A core-sheath composite cross-section fiber of 56 dtex/24 filaments was obtained in the same manner as in Example 1 except that the lubrication position was at a position of 800 mm from the lower surface of the spinneret.

[0078] For the obtained core-sheath composite cross-section fiber, the fineness, strength, degree of elongation, stress per unit fineness during 3% elongation, boiling-water shrinkage ratio, retention rate of stress during 3% elongation before and after boiling water treatment, and α-crystal orientation parameter were measured. The obtained woven fabric was evaluated for wrinkle prevention, ΔMR, ΔMR after washing, and ΔMR retention rate after washing. The results are shown in Table 1.

(Example 6)

[0079] A core-sheath composite cross-section fiber of 56 dtex/24 filaments was obtained in the same manner as in Example 1 except that the lubrication position was at a position of 1500 mm from the lower surface of the spinneret, the stretch ratio between the take-up roller and the stretching roller was 1.45 times, and the yarns were wound up at a winding speed of 3900 m/min.

[0080] For the obtained core-sheath composite cross-section fiber, the fineness, strength, degree of elongation, stress per unit fineness during 3% elongation, boiling-water shrinkage ratio, retention rate of stress during 3% elongation before and after boiling water treatment, and α-crystal orientation parameter were measured. The obtained woven fabric was evaluated for wrinkle prevention, ΔMR, ΔMR after washing, and ΔMR retention rate after washing. The results are shown in Table 1.

(Example 7)

[0081] A core-sheath composite cross-section fiber of 56 dtex/24 filaments was obtained in the same manner as in Example 1 except that the lubrication position was at a position of 800 mm from the lower surface of the spinneret, the stretch ratio between the take-up roller and the stretching roller was 1.55 times, and the yarns were wound up at a winding speed of 4100 m/min.

[0082] For the obtained core-sheath composite cross-section fiber, the fineness, strength, degree of elongation, stress per unit fineness during 3% elongation, boiling-water shrinkage ratio, retention rate of stress during 3% elongation before and after boiling water treatment, and α-crystal orientation parameter were measured. The obtained woven fabric was evaluated for wrinkle prevention, ΔMR, ΔMR after washing, and ΔMR retention rate after washing. The results are shown in Table 1.

(Example 8)

[0083] A core-sheath composite cross-section fiber of 56 dtex/24 filaments was obtained in the same manner as in Example 1 except that the circumferential speed of the take-up roller as a first roll was 2500 m/min, the stretch ratio between the take-up roller and the stretching roller was 1.65 times, and the yarns were wound up at a winding speed of 3900 m/min.

[0084] For the obtained core-sheath composite cross-section fiber, the fineness, strength, degree of elongation, stress per unit fineness during 3% elongation, boiling-water shrinkage ratio, retention rate of stress during 3% elongation before and after boiling water treatment, and α-crystal orientation parameter were measured. The obtained woven fabric was evaluated for wrinkle prevention, ΔMR, ΔMR after washing, and ΔMR retention rate after washing. The results are shown in Table 1.

(Example 9)

[0085] A core-sheath composite cross-section fiber of 56 dtex/24 filaments was obtained in the same manner as in Example 1 except that the circumferential speed of the take-up roller as a first roll was 3400 m/min, the stretch ratio between the take-up roller and the stretching roller was 1.20 times, and the yarns were wound up at a winding speed of 3900 m/min.

[0086] For the obtained core-sheath composite cross-section fiber, the fineness, strength, degree of elongation, stress per unit fineness during 3% elongation, boiling-water shrinkage ratio, retention rate of stress during 3% elongation before and after boiling water treatment, and α-crystal orientation parameter were measured. The obtained woven fabric was evaluated for wrinkle prevention, ΔMR, ΔMR after washing, and ΔMR retention rate after washing. The results are shown in Table 1.

(Comparative Example 1)

[0087] A core-sheath composite cross-section fiber of 56 dtex/24 filaments was obtained in the same manner as in Example 1 except that the heat setting temperature of the heating roller was 190°C.

[0088] For the obtained core-sheath composite cross-section fiber, the fineness, strength, degree of elongation, stress per unit fineness during 3% elongation, boiling-water shrinkage ratio, retention rate of stress during 3% elongation before and after boiling water treatment, and α-crystal orientation parameter were measured. The obtained woven fabric was evaluated for wrinkle prevention, ΔMR, ΔMR after washing, and ΔMR retention rate after washing. The results are shown in Table 2.

[0089] At this level in which the heat setting temperature of the heating roller was high, the fiber was excellent in moisture-absorbing capability and wrinkle prevention, and maintained moisture-absorbing capability even after being washed. However, contamination of the heating roller with a decomposition product of a spinning oil or the like was promoted, yarn breakage in the higher order processing steps occurred frequently, and the fiber was poor in the process passability.

(Comparative Example 2)

[0090] A core-sheath composite cross-section fiber of 56 dtex/24 filaments was obtained in the same manner as in Example 1 except that the set temperature of the stretching roller was 150°C.

[0091] For the obtained core-sheath composite cross-section fiber, the fineness, strength, degree of elongation, stress per unit fineness during 3% elongation, boiling-water shrinkage ratio, retention rate of stress during 3% elongation before and after boiling water treatment, and α-crystal orientation parameter were measured. The obtained woven fabric was evaluated for wrinkle prevention, ΔMR, ΔMR after washing, and ΔMR retention rate after washing. The results are shown in Table 2.

[0092] At this level in which the heat setting temperature of the heating roller was low, the balance of shrinkage characteristics between nylon 610 in the sheath section and the polyether ester amide copolymer in the core section was disrupted, the boiling-water shrinkage ratio was as high as 15.0%, and the woven fabric was wrinkled.

(Comparative Example 3)

[0093] A core-sheath composite cross-section fiber of 56 dtex/24 filaments was obtained in the same manner as in Example 1 except that the lubrication position was at a position of 1800 mm from the lower surface of the spinneret, the stretch ratio between the take-up roller and the stretching roller was 1.30 times, and the yarns were wound up at a winding speed of 3500 m/min.

[0094] For the obtained core-sheath composite cross-section fiber, the fineness, strength, degree of elongation, stress per unit fineness during 3% elongation, boiling-water shrinkage ratio, retention rate of stress during 3% elongation before and after boiling water treatment, and α-crystal orientation parameter were measured. The obtained woven fabric was evaluated for wrinkle prevention, ΔMR, ΔMR after washing, and ΔMR retention rate after washing. The results are shown in Table 2.

[0095] At this level in which the distance between the lower surface of the spinneret and the lubrication position was long, the rigidity of nylon 610 in the sheath section was low, the balance of shrinkage characteristics between nylon 610 in the sheath section and the polyether ester amide copolymer in the core section was disrupted, the stress per unit fineness during 3% elongation was as low as 0.58 cN/dtex, and the woven fabric was wrinkled.

(Comparative Example 4)

[0096] A core-sheath composite cross-section fiber of 56 dtex/24 filaments was obtained in the same manner as in Example 1 except that the circumferential speed of the take-up roller as a first roll was 2200 m/min, the stretch ratio between the take-up roller and the stretching roller was 1.80 times, and the yarns were wound up at a winding speed of 3800 m/min.

[0097] For the obtained core-sheath composite cross-section fiber, the fineness, strength, degree of elongation, stress per unit fineness during 3% elongation, boiling-water shrinkage ratio, retention rate of stress during 3% elongation before and after boiling water treatment, and α-crystal orientation parameter were measured. The obtained woven fabric was evaluated for wrinkle prevention, ΔMR, ΔMR after washing, and ΔMR retention rate after washing. The results are shown in Table 2.

[0098] At this level in which the take-up speed was low, the rigidity of nylon 610 in the sheath section was low, the balance of shrinkage characteristics between nylon 610 in the sheath section and the polyether ester amide copolymer in the core section was disrupted, the boiling-water shrinkage ratio was 12.3%, and the woven fabric was wrinkled.

(Comparative Example 5)

[0099] A core-sheath composite cross-section fiber of 56 dtex/24 filaments was obtained in the same manner as in Example 1 except that the circumferential speed of the take-up roller as a first roll was 3700 m/min, the stretch ratio between the take-up roller and the stretching roller was 1.05 times, and the yarns were wound up at a winding speed of 3700 m/min.

[0100] For the obtained core-sheath composite cross-section fiber, the fineness, strength, degree of elongation, stress per unit fineness during 3% elongation, boiling-water shrinkage ratio, retention rate of stress during 3% elongation before and after boiling water treatment, and α-crystal orientation parameter were measured. The obtained woven fabric was evaluated for wrinkle prevention, ΔMR, ΔMR after washing, and ΔMR retention rate after washing. The results are shown in Table 2.

[0101] At this level in which the take-up speed was high, the rigidity of nylon 610 in the sheath section was low, the balance of shrinkage characteristics between nylon 610 in the sheath section and the polyether ester amide copolymer in the core section was disrupted, the stress per unit fineness during 3% elongation was as low as 0.54 cN/dtex, the woven fabric was wrinkled, yarn breakage in the higher order processing steps occurred frequently, and the fiber was poor in the process passability.

(Comparative Example 6)

[0102] A core-sheath composite cross-section fiber of 56 dtex/24 filaments was obtained in the same manner as in Example 1 except that nylon 6 having a sulfuric acid relative viscosity of 2.40 was used in the sheath section, and the heat setting temperature of the heating roller was 150°C.

[0103] For the obtained core-sheath composite cross-section fiber, the fineness, strength, degree of elongation, stress per unit fineness during 3% elongation, boiling-water shrinkage ratio, retention rate of stress during 3% elongation before and after boiling water treatment, and α-crystal orientation parameter were measured. The obtained woven fabric was evaluated for wrinkle prevention, ΔMR, ΔMR after washing, and ΔMR retention rate after washing. The results are shown in Table 2.

[0104] At this level in which the polyamide in the sheath section was nylon 6, the rigidity of nylon 6 in the sheath section was low, the balance of shrinkage characteristics between nylon 6 in the sheath section and the polyether ester amide copolymer in the core section was disrupted, the stress per unit fineness during 3% elongation was as low as 0.53 cN/dtex, and the woven fabric was wrinkled.

[Table 1]

		Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8	Example 9
Core component	Polymer	Polyether esteramide copolymer	Polyether esteramide copolymer	Polyether esteramide copolymer	Polyether esteramide copolymer	Polyether esteramide copolymer	Polyether esteramide copolymer	Polyether esteramide copolymer	Polyether esteramide copolymer	Polyether esteramide copolymer
	OCP relative viscosity	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.69
Sheath component	Polymer	Nylon 610	Nylon 610	Nylon 610	Nylon 610	Nylon 610	Nylon 610	Nylon 610	Nylon 610	Nylon 610
	Sulfuric acid relative viscosity	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72
Yarn making conditions	Take-up speed (m/min)	2,800	2,800	2,800	2,800	2,800	2,800	2,800	2,500	3,400
	Stretch ratio	1.50	1.50	1.50	1.50	1.50	1.45	1.55	1.65	1.20
	Winding speed (m/min)	4,000	4,000	4,000	3,900	4,000	3,900	4,100	3,900	3,900
	Lubrication position (mm)	1,000	1,000	1,000	1,500	800	1,500	800	1,000	1,000
	Heat setting temperature (°C)	170	180	165	170	170	170	170	170	170

(continued)

		Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8	Example 9
Mechanical characteristics of fiber	Fineness (dtex)	56	56	56	56	56	56	56	56	56
	Strength (cN/dtex)	3.6	3.7	3.5	3.6	3.6	3.2	3.0	3.8	3.5
	Degree of elongation (%)	43	39	45	39	48	46	42	44	44
	Boiling-water shrinkage ratio (%)	9.8	6.1	11.8	9.7	9.8	10.0	9.7	10.5	9.0
	Stress during 3% elongation (cN/dtex)	0.82	0.83	0.79	0.81	0.82	0.72	0.85	0.86	0.67
	Stress during 3% elongation (cN/dtex) after boiling water treatment	0.60	0.59	0.51	0.59	0.59	0.51	0.62	0.59	0.49
	Retention rate of stress during 3% elongation (%) after boiling water treatment	73	71	65	73	72	71	73	69	73
	α-Crystal orientation parameter	2.53	2.60	2.45	2.50	2.56	2.39	2.64	2.10	2.70
Process passability through higher order processing steps	Yarn breakage (times)	1	2	1	1	1	1	2	1	2

(continued)

		Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8	Example 9
Evaluation of fabric	Wrinkle prevention	5	5	3	5	5	4	5	3	4
	ΔMR (%)	10.2	10.3	10.0	9.8	10.4	9.6	11.0	9.5	10.7
	ΔMR after washing (%)	10.1	10.2	9.8	9.5	10.3	9.2	10.9	9.1	10.6
	ΔMR retention rate after washing (%)	99	99	98	97	99	96	99	96	99

[Table 2]

		Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4	Comparative Example 5	Comparative Example 6
Core component	Polymer	Polyether ester amide copolymer	Polyether ester amide copolymer	Polyether ester amide copolymer	Polyether ester amide copolymer	Polyether ester amide copolymer	Polyether ester amide copolymer
	OCP relative viscosity	1.69	1.69	1.69	1.69	1.69	1.69
Sheath component	Polymer	Nylon 610	Nylon 610	Nylon 610	Nylon 610	Nylon 610	Nylon 6
	Sulfuric acid relative viscosity	2.72	2.72	2.72	2.72	2.72	2.40
Yarn making conditions	Take-up speed (m/min)	2,800	2,800	2,800	2,200	3,700	2,800
	Stretch ratio	1.50	1.50	1.30	1.80	1.05	1.50
	Winding speed (m/min)	4,000	4,000	3, 500	3, 800	3,700	4,000
	Lubrication position (mm)	1,000	1,000	1,800	1,000	1,000	1,000
	Heat setting temperature (°C)	190	150	170	170	170	150

(continued)

		Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4	Comparative Example 5	Comparative Example 6
Mechanical characteristics of fiber	Fineness (dtex)	56	56	56	56	56	56
	Strength (cN/dtex)	3.8	3.2	3.0	4.0	3.3	3.2
	Degree of elongation (%)	36	48	50	43	45	45
	Boiling-water shrinkage ratio (%)	4.8	15.0	10.3	12.3	8.7	16.3
	Stress during 3% elongation (cN/dtex)	0.83	0.79	0.58	0.58	0.54	0.53
	Stress during 3% elongation (cN/dtex) after boiling water treatment	0.60	0.52	0.40	0.40	0.38	0.28
	Retention rate of stress during 3% elongation (%) after boiling water treatment	72	66	69	69	70	53
	α-Crystal orientation parameter	2.72	2.25	2.20	1.80	2.05	2.12
Process passability through higher order processing steps	Yarn breakage (times)	16	1	2	1	10	1
Evaluation of fabric	Wrinkle prevention	5	2	2	2	2	2
	ΔMR (%)	10.3	10.0	9.5	8.5	11.0	12.2
	ΔMR after washing (%)	10.2	9.8	9.2	7.8	10.9	12.1
	ΔMR retention rate after washing (%)	99	98	97	92	99	99

Claims

1. A core-sheath composite cross-section fiber, comprising:

   a thermoplastic polymer as a core polymer; and a polyamide having a dicarboxylic acid unit having, as a main component,
   a sebacic acid unit as a sheath polymer, the core-sheath composite cross-section fiber having a boiling-water shrinkage ratio of 6.0 to 12.0%, and a stress per unit fineness during 3% elongation in a fiber tensile test of 0.60 cN/dtex or more.

2. The core-sheath composite cross-section fiber according to claim 1, wherein a sheath section has an α-crystal orientation parameter of 2.10 to 2.70.

3. The core-sheath composite cross-section fiber according to claim 1 or 2, having a retention rate of stress per unit fineness during 3% elongation in a fiber tensile test of 60% or more before and after boiling water treatment.

4. A fabric comprising the core-sheath composite cross-section fiber according to any one of claims 1 to 3 in at least a part thereof.

5. A textile product comprising the core-sheath composite cross-section fiber according to any one of claims 1 to 3 in at least a part thereof.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/082368

A. CLASSIFICATION OF SUBJECT MATTER
D01F8/12(2006.01)i, *D03D15/00*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
D01F8/00-8/18, D03D1/00-27/18

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2017
Kokai Jitsuyo Shinan Koho 1971-2017 Toroku Jitsuyo Shinan Koho 1994-2017

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2007-169849 A (Toray Industries, Inc.), 05 July 2007 (05.07.2007), claims; examples & US 2009/0068463 A1 claims; examples & WO 2007/046397 A1 & EP 1939336 A1 & KR 10-2008-0059232 A & CA 2625343 A	1-5
A	JP 2001-159030 A (Toray Industries, Inc.), 12 June 2001 (12.06.2001), claims; table 1 (Family: none)	1-5

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 January 2017 (13.01.17)	31 January 2017 (31.01.17)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/082368

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 50-48216 A (Asahi Chemical Industry Co., Ltd.), 30 April 1975 (30.04.1975), claims; examples (Family: none)	1-5
A	WO 2015/129735 A1 (Toray Industries, Inc.), 03 September 2015 (03.09.2015), claims; table 1 & CA 2939217 A & CN 106062262 A & KR 10-2016-0124094 A	1-5
E,A	WO 2016/190102 A1 (Toray Industries, Inc.), 01 December 2016 (01.12.2016), claims; tables 1, 2 (Family: none)	1-5

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 6136618 A **[0008]**
- WO 2008123586 A **[0008]**